Latitudinal Survey of VLF Emissions during the JARE South Pole Traverse 1968–69

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1. Introduction

VLF emissions at high latitudes can roughly be classified into two types, hiss and polar chorus. Hiss with a wide frequency spectrum above 2 kHz is usually observed at night, and it is closely related to the appearance of aurora (MARTIN *et al.*, 1960; MOROZUMI, 1963). In the daytime a quasi-steady noise with risers is usually observed below 2 kHz, and this is known as polar chorus or ELF hiss (UNGSTRUP and JACKEROTT, 1963; TAYLOR and GURNETT, 1968; KOKUBUN *et al.*, 1969). The local time dependence of these emission occurrences is shown in Fig. 1. The occurrence probability of hiss is high along the evening portion of the so-called auroral oval, whereas polar chorus is observed near the precipitation zone of energetic electrons. This pattern is rather statistical and does not necessarily show the spatial extent of an indivisual emission event. Recent-

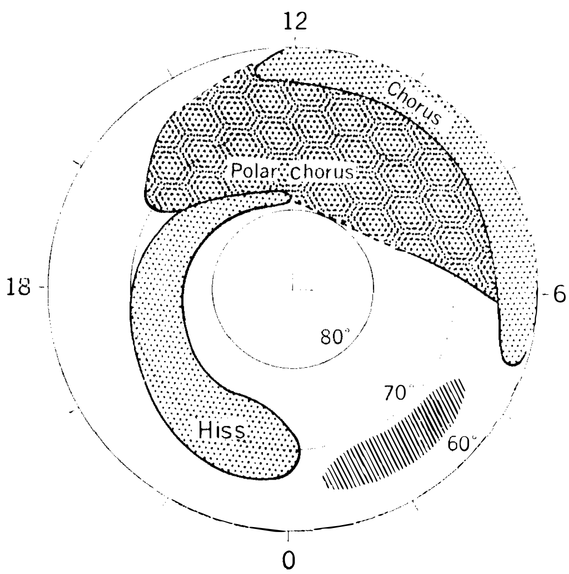

Fig. 1. Local time dependence of VLF emissions.

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ly, much attention has been paid to the study of interrelations among VLF hiss and other auroral-zone phenomena, association between polar chorus and magnetic variations, and electron precipitation events. However, little research has been made to clarify spatial characteristics of VLF emission events. In connection with spatial distribution of hiss at high latitudes, HARANG (1968) has reported that hiss spikes observed at 800 km northward of the northern auroral-zone does not always coincide with hiss activity at the auroral-zone stations. Such a spatial correlation for polar chorus event has not yet been dealt with. The observation of electromagnetic noise in the VLF and LF ranges at Syowa Station (69°02'S, 39°36'E; −69.6°, 77.1°) has been carried out as one of the projects for studying auroral-zone upper-atmosphere phenomena since February, 1966. Various devices for recording spectral characteristics and intensity variation in VLF emissions (KOKUBUN *et al.*, 1969) have been operated, and also measurements of polarization and arrival direction of VLF waves have been carried out (NISHINO and TANAKA, 1969). The direction observation is a useful method for examining the spatial characteristics of VLF emissions, and observations at separated positions is most useful for clarifying the spatial dependence. Thus, we planned a latitudinal survey of VLF emissions during the traverse from Syowa Station to the South Pole in 1968-1969. The main purpose of this observation was the recording of polar chorus emissions, because hiss is observed mostly in winter. The traverse covered the latitude ranges between 69° and 80° in geomagnetic coordinates, in which the statistical polar chorus zone is included as shown in Fig. 1.

2. Instrument

Much care was taken in the instrumental construction against low-temperature and vibration on board a snow vehicle. The instrument was designed for automatic recording of VLF emission in the frequency range of 100-10 kHz on the hourly routine basis. The device consists of a loop antenna, a preamplifier, a filter, a magnetic tape recorder, and a crystal clock, as shown in the block

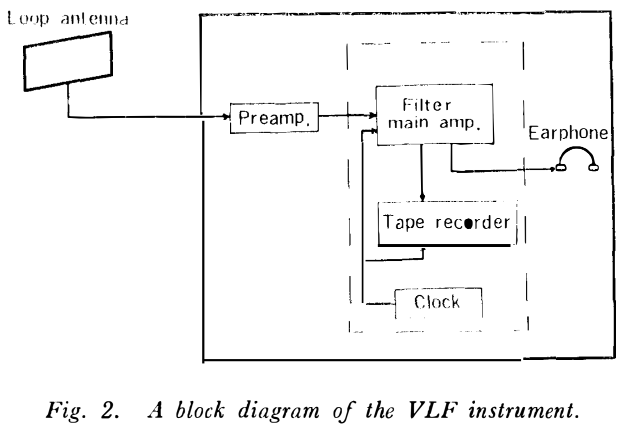

Fig. 2. A block diagram of the VLF instrument.

Table 1. Characteristics of electronic devices.

Preamplifier	Input impedance	150Ω balanced
	Voltage again	70 dB
	Noise level	Below −136 dB
	Frequency response	100 Hz∼10 kHz ±1 dB
Main amplifier	Voltage gain	60 dB
	Attenuator	5 dB 8 step
	Frequency response	Voltage gain at 17 kHz is −40 dB or less against that of the pass band of 100 Hz∼10 kHz
	Output	Capable of monitoring by earphone
Tape recorder	Tape speed	9.5 cm/s
	Tape width	6.25 mm
	Reel size	5 or 3 inch
	Channel number	1, double track
Crystal clock	Stability	10^{-6}
	Program signal	1 s (electric signal) 49 min, 50 min, 50 min 30 s, 51 min, 51 min 30 s, 52 min (relay signal)

diagram of Fig. 2. The antenna is a 50-turn loop of 1 mm diam. copper wire, wound on a wooden frame of 1.50×4.54 m. The effective area is about 280 m^2. This antenna was installed vertically on an iron sledge, which carried kerosene drums. The preamplifier and other devices were settled on the rear side of the snow vehicle. The antenna and preamplifier were connected with a balanced coaxial cable. Characteristics of electric devices are summarized in Table 1.

The input impedance of the preamplifier is 150 Ω, the noise level being below −136 dB at the input. This noise level is equivalent to the electromagnetic flux of the order of $<10^{-16}$ w/m^2 Hz, induced in the loop antenna. The maximum flux of polar chorus observed at the ground is 10^{-14} w/m^2 Hz or greater. Then a signal to noise ratio of $\gtrsim$20 dB is attained for usual chorus activity. The frequency response of the amplifiers was restricted within a range of 100-10 kHz, using a sharp high-cut filter above 10 kHz in order to avoid interferences from artificial electromagnetic signals near 20 kHz.

A tape recorder of DC-operated servo-motor type was used, as the available power source was a DC 24 V battery of the snow vehicle. In order to drive the tape recorder for 2 minutes every hour, from 50 to 52 minutes, time signals from a crystal clock of stability 10^{-6} was utilized. Every 30 seconds from 50 minutes, 2 kHz sine wave of 100 millisecond duration was recorded as the time marks on the magnetic tape together with the observed VLF signals.

Table 2. Period of VLF observation.

Period (1968-69)	Remarks
Sept. 29-Oct. 3	From Syowa to the Plateau Station The traverse operation was stopped due to an injury of a party member on Oct. 3. Readjustments of the VLF instrument were done at Syowa Station, as the KD605 snow vehicle went back to the station.
Oct. 13-Oct. 26	On Oct. 9 disconnections of the antenna wire was noticed. Repairs were made on Oct. 13.
Oct. 27-Nov. 12	The antenna was transferred from the iron sledge to the wooden sledge on Oct. 26, because of breakdown of the iron sledge.
Nov. 16-Dec. 18	From the Plateau Station to the Pole.
Dec. 25-Jan. 17	From the Pole to the Plateau Station on the way back to Syowa Station, the VLF observation was made only when the snow vehicle stopped after daily work.
Jan. 20-Feb. 11	From the Plateau Station to Syowa.

3. Observation

A preliminary test of VLF observation in a snow vehicle of KD60 type was performed near the Sôya Coast in November, 1966. It was found that pulsive noises below 2 kHz were generated possibly from the dynamo of the vehicle. This artificial noise exceeded the natural electromagnetic signals induced in a loop antenna. Therefore, it was concluded that the measurement of VLF emissions was impossible while the engine of the vehicle was in operation, and the hourly observation was to be conducted in principle when the engine was switched off.

The actual observation on the way from Syowa Station to the South Pole began at St. 22, on September 29, 1968, and ended on February 11, 1969. The observation was carried out during almost the entire period of the traverse, though it was often interrupted due to various troubles in the instrument. The observation periods are listed in Table 2. Troubles were mainly caused by rapid temperature variations inside the vehicle, and by disconnections of the antenna circuit. One of the serious troubles happening in the beginning of the traverse was a disconnection of the antenna wire. As a complete repair of the antenna was practically impossible, the longest part of the loop winding was connected with the preamplifier as a temporary expedient. Interruptions of the observation were sometimes due to snow vehicle operations, for example, when the vehicle engine could not be switched off, or the sledge was often to be separated while the vehicle travelled over deep snow regions near the Mizuho Plateau.

4. Conclusion

After examination of the data, we notice that their quality is not necessarily satisfactory. This seems to be mainly due to the antenna disconnection which happened in the early stage of the traverse, and partly to the insufficient stability of the instrument in low temperature conditions. Since it is very important to observe VLF emissions at separated places, we will carry on VLF observations in the Antarctic Continent in future also, basing upon valuable experiences in this traverse. Concerning this subject, it is worth mentioning that an observation of VLF emissions is also being made during the survey of the Antarctic Continent by the JARE wintering party, 1969-70. The instrument of this JARE 1969-70 observation is the same as described here, but some improvements were made by K. HAYASHI at Syowa Station. Simultaneous observations at Syowa Station and St. 170 were successful, and the result will be reported in a future issue of Antarctic Record (HAYASHI, 1971).

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